CHART PROGRAM

CHART WEB
SYSTEM ARCHITECTURE

Version 4.0

Doc# CWEB-OPS-003

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Document Revisions

Revision	Description	Pages Affected	Date
1	Initial Release	All	5/12/2016
2		All	6/17/2016
3	WO 12 Public Mobile Video. Updated cover Updated document references Updated diagrams Rework Business Architecture Update Release History Miscellaneous edits	 pp. 2, 3 pp.13, 15,21, 24, 25, 31 pp. 42, 45 pp. 56, 57 pp. 33, 47, 48	6/15/2017
4	Document review and updates for R3.5	All	8/8/2017

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1 INTRODUCTION

1.1 Purpose

This document presents the architecture of the Coordinated Highways Action Response Team (CHART) CHARTWeb application. The architecture of the CHARTWeb application is presented as a number of different "views", with each view representing a different perspective of the system.

1.2 Views Descriptions

Each view is described in Table 1-1. In addition, there are various appendices, described in Table 1-2.

Table 1-1. CHARTWeb Architecture Document Views

View Name	Description	Typical Stakeholders	Section
Feature List View	Provides a brief high-level overview of the CHARTWeb application and describes the features available in the system	Representatives from other agencies interested in the CHARTWeb application capabilities, as well as operators, support personnel, developers, and managers	2
Functional View	Describes basic CHARTWeb application functionality and some key operational concepts that drove how the functionality has been implemented	Developers, managers and officials from other organizations, looking to interface with or build a system like the CHARTWeb application	3
System View	Shows system components and how they connect to each other	System administrators, software developers and architects and others interested in the system-level architecture	4
Interface View	Describes the CHARTWeb application external interfaces	Representatives from other agencies interested in the CHARTWeb application capabilities, specifically software and system architects who may be looking to interface with the CHARTWeb application	5
Data View	Describes how data moves into, out of, and around the CHARTWeb application	Database administrators (DBAs), management, developers, and stakeholders of connected systems	6
Deployment View	Describes the various CHARTWeb application deployment configurations	Operations & Maintenance personnel, network engineers	7

View Name	Description	Typical Stakeholders	Section
Subsystem View	Describes the CHARTWeb application software/ hardware subsystems and Commercial Off-The-Shelf (COTS) products	Developers, configuration managers, and management	8
Standards View	Describes the CHARTWeb application support for mapping interface standards.	MDSHA management, developers, and those looking to interface with CHART Mapping for the purpose of consuming/display CHARTWeb application data.	9
Business Architecture View	Describes the CHARTWeb application from a business process perspective	Business Area Architecture (BAA) process participants, those interested in CHART's business plan and its mapping to the CHARTWeb application capabilities	10
System Maintenance View	Describes Operations and Maintenance aspects of the CHARTWeb application	System administrators, software and system architects, others interested in CHARTWeb application maintenance tasks	11

Table 1-2. CHARTWeb application Architecture Document Appendices

Appendix	Description
A	Design studies performed during the development of the CHARTWeb application
B	Database entity-relationship (ER) diagrams describing the design of the CHARTWeb application database
C	Release history of the CHARTWeb application

1.3 Applicable Documents

Relevant documents associated with the system architecture are listed in the Table 1-3 below.

Table 1-3. Document References

Requirements and Vision
CHARTWeb R3.3 Mapping R17.3 AVL-GPS R2.3 ATMS R17.1 Software Requirements, Version 2.0, February 13, 2017, WO12-CHART-RD-001-V2.0, WO14 Del 8 CHART Web R3.5 Requirements
2016 Business Area Architecture Revision 17, March 15, 2017, CHART-OPS-014-v17
Design
CHARTWeb R3.3 Mapping R17.3 AVL-GPS R2.3 ATMS R17.1 System Design Document,

Version 1.0, February 20, 2017, WO12-CHART-RD-002-V1.0, WO14 Del 8 CHART Web R3.5 Detailed Design
Studies
CHART System Database Strategic Plan, April 21 2011
Operations and Maintenance
CHARTWeb Operations and Maintenance Guide, Version 15.0, March 22, 2017, CWEB-OPS-001-V15.0
Configuration Management
CHART Change Management Plan, December 22, 2016, CHART-OPS-003v1.0

2 FEATURE LIST VIEW

2.1 View Description and Typical Stakeholders

This view provides a brief high-level overview of the CHARTWeb application and describes the features available in the system. This section is suitable for those who would like to have an easy-to-digest list of features the CHARTWeb application provides, such as representatives from other agencies interested in the CHARTWeb application capabilities, as well as operators, support personnel, developers, and managers just coming in who are new to the CHARTWeb application, or who would like a quick refresher.

2.2 CHARTWeb application Overview

The CHARTWeb application consists of the CHARTWeb public internet web site, sometimes referred to as CHARTWeb Desktop. This application resides in the CHART DMZ and provides data to the public via the web. CHARTWeb Desktop delivers data to audiences using standard desktop web browsers as well as mobile device browsers.

The CHARTWeb Desktop application resides on the DMZCHARTWEB server in the CHART DMZ. This server runs on Windows Server 2008R2 and utilizes PHP 5.6.2, .NET Framework 4.5, ASP 3.0, CSS, JavaScript/JQuery and HTML 5. For information that is displayed on the CHARTWeb Desktop internet map, data is retrieved by direct JavaScript calls to the CHART Data Exporter which also resides in the CHART DMZ on the CHARTEXP2 server. Data for HTML, XML and RSS output is retrieved via JavaScript calls to the CHART Data Exporter as well as direct database queries through a firewall to the CHARTWeb Public database which resides on the inside of the MDOT network.

The data sets shared by CHARTWeb includes:

- Traffic Cameras – Provides the ability to view live, streaming traffic video feeds.
- Maryland Highway and Traffic Information where the public can view reported traffic incidents, weather road closures, active construction and maintenance closures information.
- Planned Lane Closures where the public can view planned lane closures in Maryland.
- Route Restrictions where the public can view a list of Maryland State Route Restrictions
- Local Weather Station Data where the public can view current weather data from CHART System Weather Stations.
- Speed Sensor Data where the public can view current traffic speeds from CHART system Speed Sensors.
- Highway Message Signs where the public can view current highway advisory messages from CHART dynamic message signs.
- Snow Emergency Plans where the public can view the list of Maryland counties in a declared state of snow emergency.

- Weather Related Road Conditions provides the travel conditions for interstate, primary and secondary routes.RSS and XML Feeds where the public can view and subscribe to CHARTWeb RSS and XML data feeds.
- Current weather conditions including current temperatures, local forecasts and tropical weather.
- AVL – Automatic Vehicle Locator data is available for display on the CHARTWeb Map, if configured to do so.
- Interactive Map which provides a Google Map based user interface displaying location and data for incidents, speed sensors, road closures, traffic video cameras, dynamic message signs, route restrictions, highway advisory radio and area wide conditions.

3 FUNCTIONAL VIEW

3.1 View Description and Typical Stakeholders

This view into the CHARTWeb application describes basic functionality and some key operational concepts that drove how the system was constructed. This is not a User's Guide or tutorial. Although there are some design concepts presented, it does not get to the level of a formal design document. This view is useful for anyone interested in how the CHARTWeb application works at a high level, including developers, SHA management, MDOT management, and officials from other organizations, looking to interface with or build a system like the CHARTWeb application.

3.2 Traffic Cameras

Live traffic video streams are provided to the CHARTWeb application via video streaming servers. Currently HTTP Live, RTMP and RTSP video formats are provided for streaming to both desktop browsers and mobile devices.

3.3 Maryland Highway and Traffic Information

The Maryland Highway and Traffic Information module provides current traffic incident, road work, weather events, disabled vehicle events, action event, traffic congestion events and special event events to the CHARTWeb application. The road work data contains information from the CHART ATMS and the Lane Closure Permits (LCP) application. All other types of data shown originate exclusively from the CHART ATMS application. This module does not provide a map based interface, rather all data is shown in a tabular text based format along with lane diagram images where available. All data displayed in this user interface is received by direct queries through a firewall to the CHARTWeb database located inside of the MDOT network. The CHARTWeb database receives its data from data export clients designed to provide data from the CHART ATMS and LCP applications in near real-time.

3.4 Planned Lane Closures

The Planned lane closure data module provides current LCP lane closure data to the CHARTWeb application for closures which are approved to be active but currently are not. The CHARTWeb application receives this data from the CHARTWeb database which gets the data from the LCP data exporter on the MDOT network.

3.5 Route Restrictions

The Route Restrictions module displays route restriction, sometimes referred to as hauling restrictions, on the CHARTWeb Desktop web site. This data is retrieved via direct SQL queries through the firewall from the CHARTWeb Public database. This data originates in the EORSV2 application and is provided to the database through SQL Agent jobs that run every 2 minutes.

3.6 Local Weather Station Data

The Local Weather Station module displays RWIS based weather station on the CHARTWeb Desktop web site. This data is retrieved via direct SQL queries through the firewall from the

CHARTWeb Public database. This data originates in the Lufft application and is provided to the database through a MSSQL Linked Server connection.

3.7 Speed Sensor Data

The Speed Sensor Data module displays Traffic Speed Sensor (TSS) data on the CHARTWeb Desktop web site. This data is retrieved via direct SQL queries through the firewall from the CHARTWeb Public database. This data originates in the CHART ATMS application and is provided to the database through a data exporter which provides updates in near real-time.

3.8 Highway Message Signs

The Highway Message Signs modules displays Dynamic Message Sign (DMS) data on the CHARTWeb Desktop web site. This data is retrieved via direct SQL queries through the firewall from the CHARTWeb Public database. This data originates in the CHART ATMS application and is provided to the database through a data exporter which provides updates in near real-time.

3.9 Snow Emergency Plans

The Snow Emergency module displays current and recently lifted snow emergency plans on the CHARTWeb Desktop web site. This data is retrieved via direct SQL queries through the firewall from the CHARTWeb Public database. This data originates in the EORSV2 application and is provided to the database through SQL Agent jobs that run every 2 minutes.

3.10 Weather Related Road Conditions

The Weather Related Road Conditions module displays current road conditions for Interstate, Primary and Secondary (IPS) routes in Maryland on the CHARTWeb Desktop web site. This data is retrieved via direct SQL queries through the firewall from the CHARTWeb Public database. This data originates in the EORSV2 application and is provided to the database through SQL Agent jobs that run every 2 minutes.

3.11 AVL Data

Automatic Vehicle Locator data is available to CHARTWeb users on a Winter Operations Vehicles Video Map, if CHARTWeb is configured to show that map. Users view locatios of select vehicles via the CHART Export Client JSON feed. This data originates from the AVL-GPS Server application. Note that as of Spring, 2017, CHARTWeb is not configured to show the Winter Operations Vehicles Map.

3.12 RSS and XML Feeds

The RSS and XML Feeds Modules provide the ability to share CHARTWeb data using the CHARTWeb Desktop web site in both RSS and XML formats. This module provides data feeds for traffic incidents, road closures, traffic speeds, RWIS weather stations, highway message

signs, snow emergency plans and live traffic cameras. This data is retrieved via direct SQL queries through the firewall from the CHARTWeb Public database.

3.13 Interactive Mapping

The CHARTWeb Desktop Interactive Mapping module uses a Google Map to display travel related data to the public. The application utilizes the OpenLayers JavaScript library to support the integration of Google Maps and layered CHART program data. The Interactive Map receives real-time device and incident data such as HAR, TSS, DMS, CHART Closures, Weather Station data, Snow Emergency Plans, Road Condition data, Route Restrictions, and AVL data and CHART Incidents data from the CHART ExportClient via a JSON feed.

4 SYSTEM VIEW

4.1 View Description and Typical Stakeholders

The System View describes what the CHARTWeb application hardware components are, how they are configured, what they support, and how they connect to each other. This view focuses on the internal structure of the system and its components (the view from within), whereas the Interface View focuses on external interfaces (the view from outside). This view will be of primary use to system administrators, software developers and architects and others interested in the system-level architecture.

4.2 System Overview

4.2.1 CHART Description

Figure 4-1 presents an overview of the CHART Program Architecture organized according to the Enterprise Architecture Framework as defined by the National Institute of Standards and Technology and how the CHARTWeb application fits within it. This approach gives a holistic view of the enterprise and is organized into 5 layers:

Enterprise Business Architecture Layer

Enterprise Information Architecture Layer

Enterprise Application Architecture Layer

Enterprise Application Integration Architecture Layer

Enterprise Infrastructure Architecture Layer

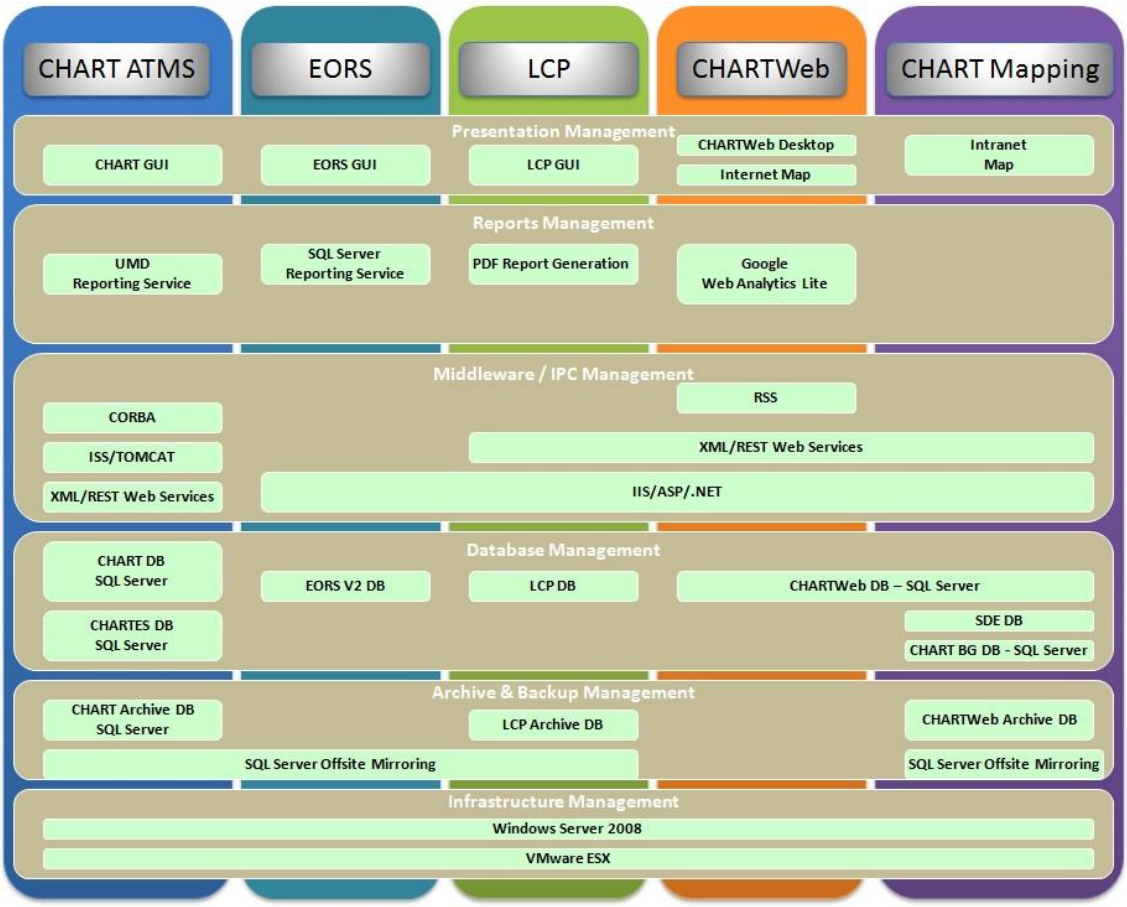

Figure 4-1. CHART Architectural Overview

The next two diagrams show various views of the CHART system architecture and how the CHARTWeb application fits within it. Figure 4-2 presents a high-level connection oriented architecture diagram showing how all of the internal and external systems connect to each other. Figure 4-3 presents a more detailed view of the components specific to the CHARTWeb application.

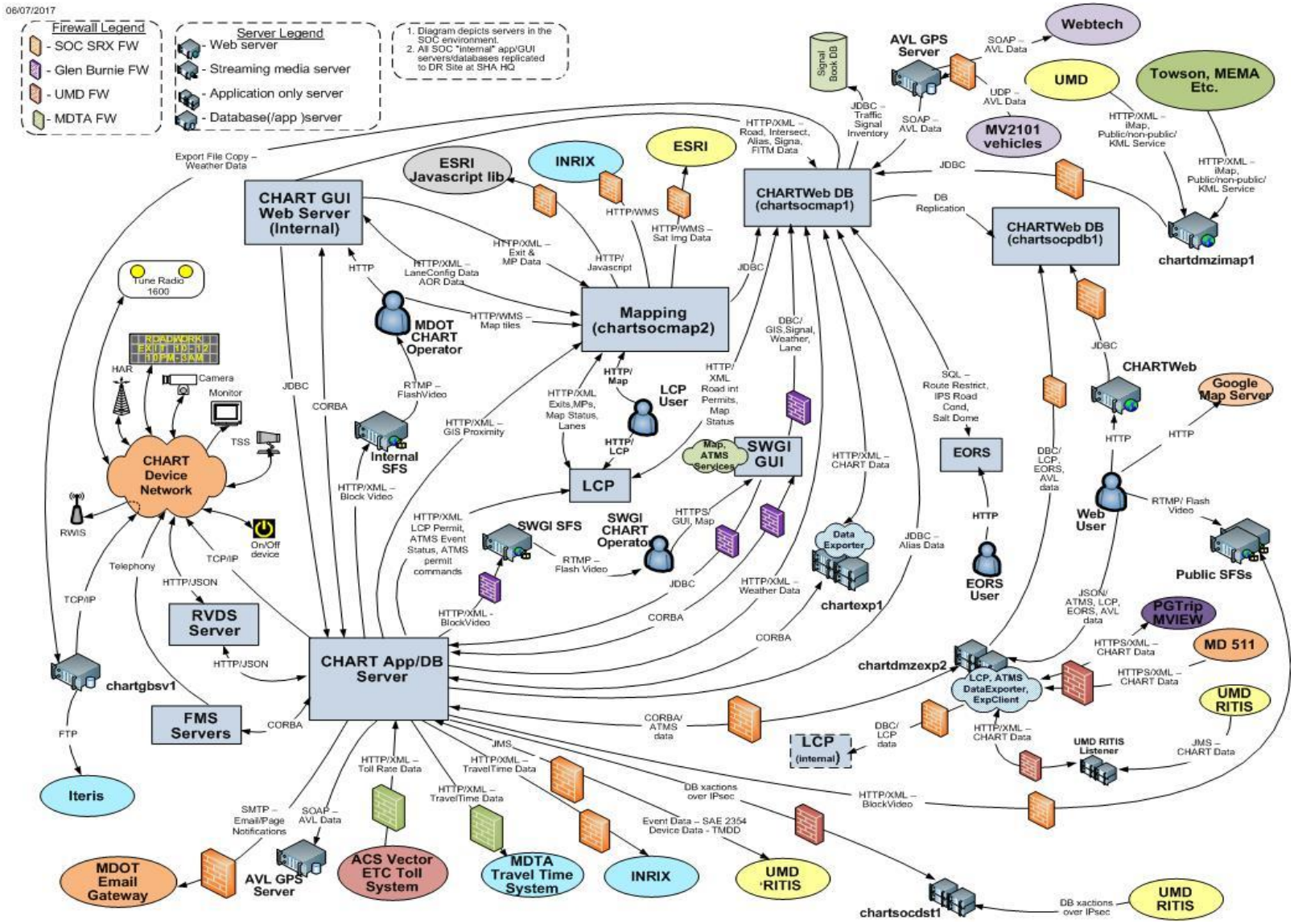

Figure 4-2. High Level CHART Systems Architecture

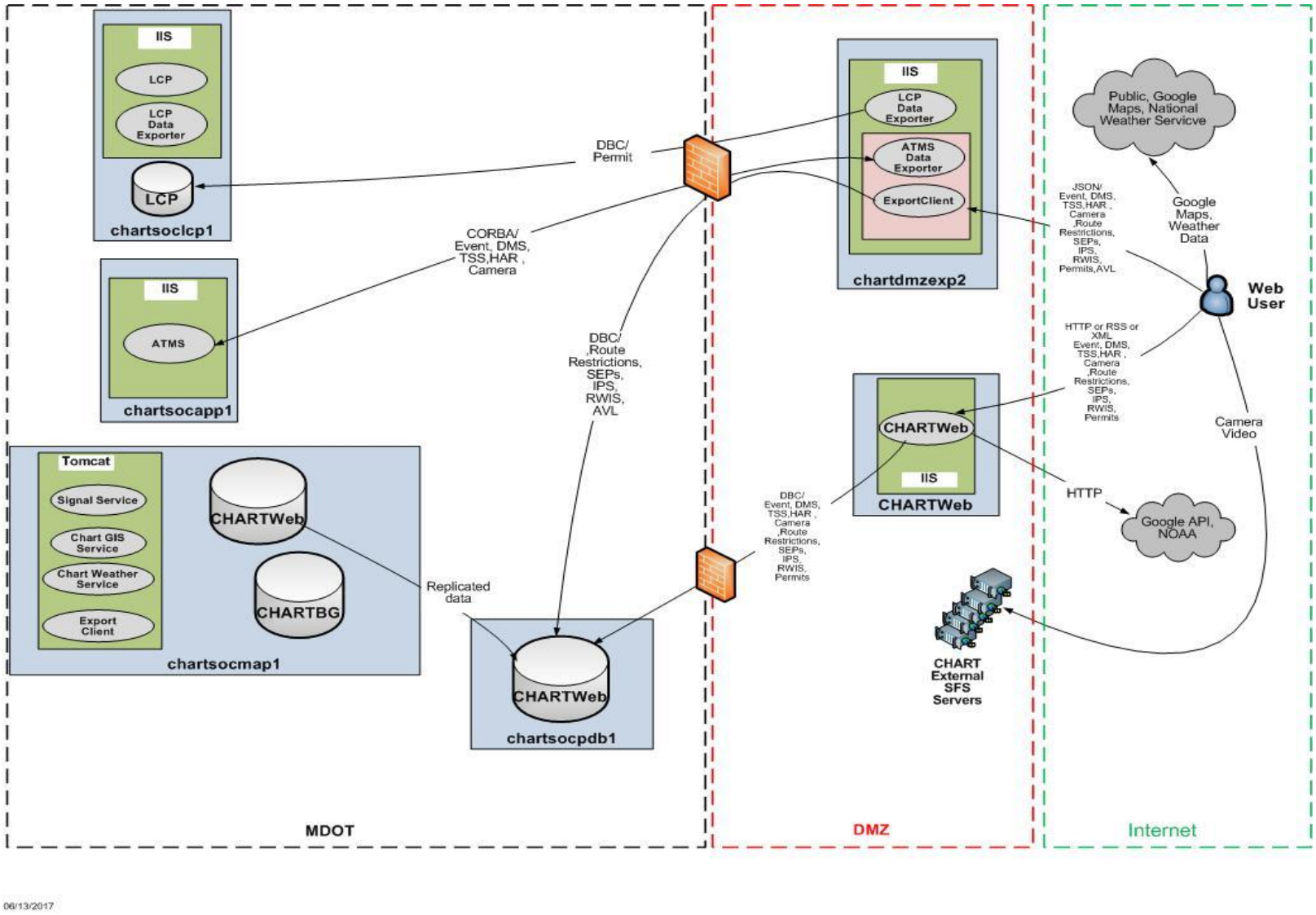

Figure 4-3. CHARTWeb application Detailed System Architecture (connect oriented)

4.3 Software components

4.3.1 Software CIs

There are 3 software CIs comprising the CHARTWeb application.

CHARTWeb Desktop Web Site – This CI consists of the full desktop version of the CHARTWeb web site including the internet based map.

DMZ Data Exporter – This CI consists of those services which provide data to the CHARTWeb mapping application.

4.3.2 Communications

4.3.2.1 Database communications

The CHARTWeb Desktop application executes SQL queries directly to the CHARTWeb Public MSSQL database located inside of the MDOT network.

4.4 Database

The overall CHARTWeb database architecture is shown in Figure 4-4.

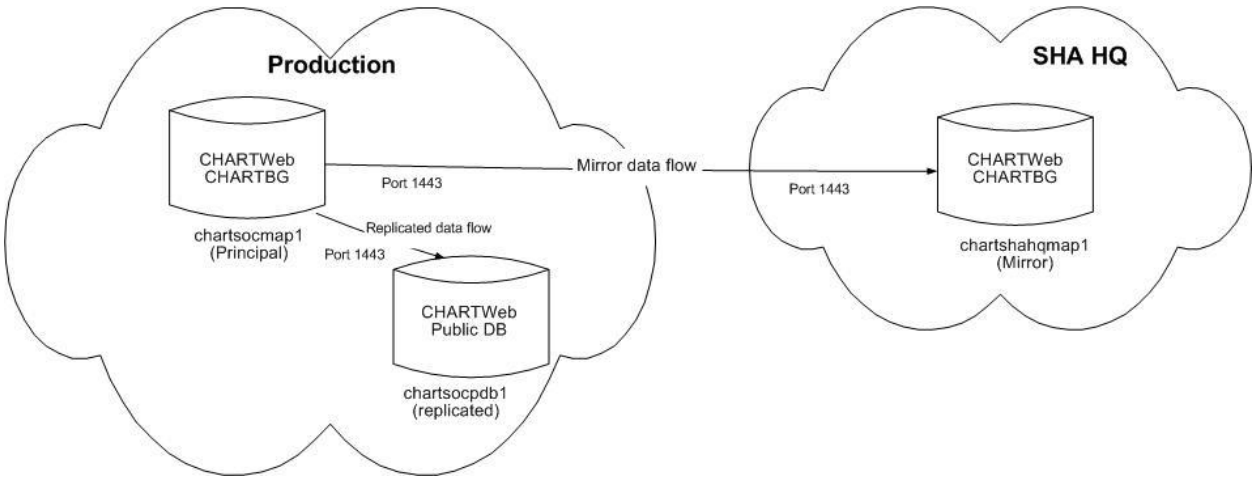

Figure 4-4. CHARTWeb Database Architecture

Both databases are mirrored to SHA Headquarters. The mirror databases are used for disaster recovery scenarios.

4.4.1 Mirroring

The CHARTWeb database is mirrored from the Principal location at the SOC to the Mirror location at SHA Headquarters (HQ). This provides a duplicate copy of each database at SHA Headquarters, to be used by CHARTWeb services running at the SHA Headquarters failover site. This service is not running routinely. Before they can run, the mirrored databases at SHA Headquarters must be set to be Principal.

4.5 Hardware components

This section presents the hardware CIs that make up the CHARTWeb application. Each hardware CI is described and a list of major components is provided.

4.5.1 Hardware CIs

There are two hardware CIs for the CHARTWeb applications.

CHARTWeb Desktop Application Web Server – Supports the CHARTWeb Desktop web site code base that receives data from the CHARTWeb database and ATMS data exporters.

4.5.2 CHARTWeb Application Server Descriptions

The CHARTWeb Desktop application server system supports the CHATRTWeb Desktop software CIs. This system consists of a single stand alone virtual server along with associated storage array and network connection devices. This system is currently deployed in a virtual environment at the MDOT Glen Burnie data Center (GB-DC).

The CHARTWeb Desktop Application Server system configuration is:

Intel XEON X5650 2 processor 2.67 GHz

8 GB Total SDRAM

100 GB C drive; 100 GB D: drive

DVD Drive

Gigabit NIC card

5 INTERFACE VIEW

5.1 View Description and Typical Stakeholders

The Interface view describes connections to systems and users outside of CHARTWeb. CHARTWeb has external connections to ingest data for use in the CHARTWeb applications. It also has interfaces to provide data to external entities that may then re-package the information for presentation to their end-users.

Typical stakeholders of this section are representatives from other agencies interested in CHARTWeb's capabilities, specifically software and system architects who may be looking to interface with CHARTWeb.

5.2 External Interfaces

Figure 5-1 shows the external interfaces to the CHARTWeb applications.

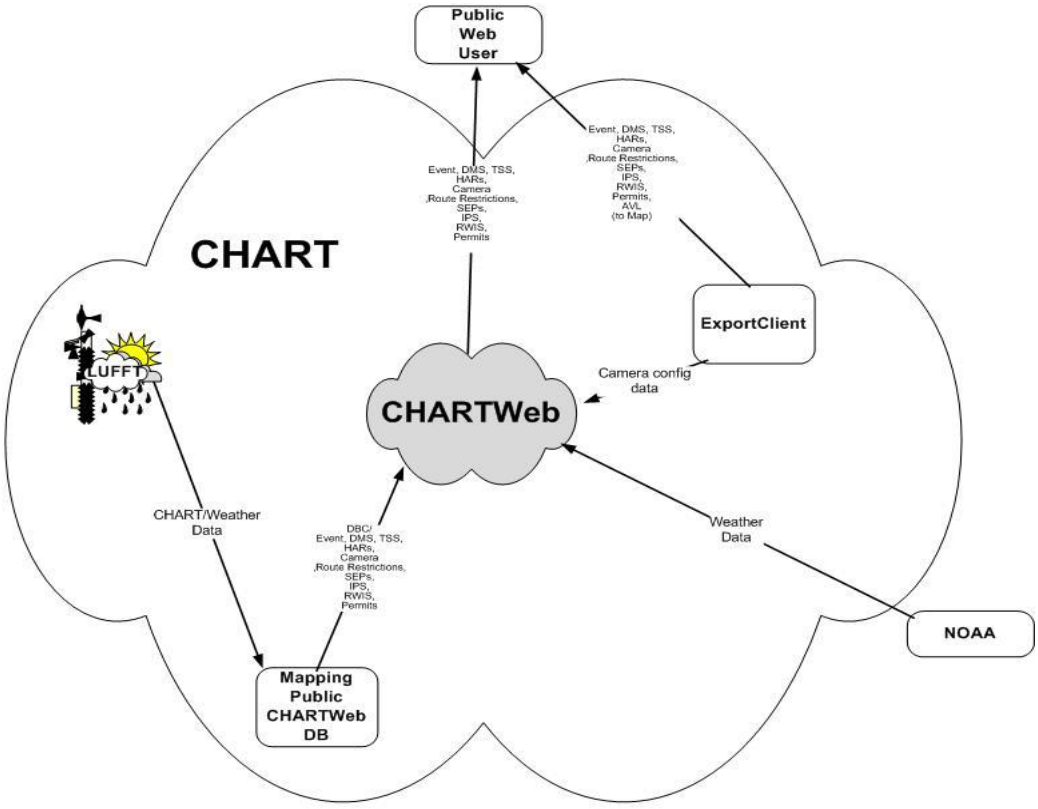

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Figure 5-1. CHARTWeb External Interfaces

CHARTWeb's external interfaces consist of:

Public Web Users – This public-facing site displays CHARTWeb Data via a standard web based HTML user interface. In addition, the CHARTWeb Desktop Application provides data through RSS and XML feeds.

NOAA – The CHARTWeb Desktop application queries NOAA for weather forecasts and current conditions for display to Public Web User.

6 DATA VIEW

6.1 View Description and Typical Stakeholders

This view into CHARTWeb shows how data moves into, out of, and around CHARTWeb and describes at a high level how CHARTWeb data is stored in the operational databases associated with the CHARTWeb application. This view is useful for CHARTWeb DBAs, management, developers, and stakeholders affiliated with the various systems with which the CHARTWeb application interfaces.

6.2 Data Flow

Data flows for the CHARTWeb application are illustrated in Figures 6-1 and 6-2.

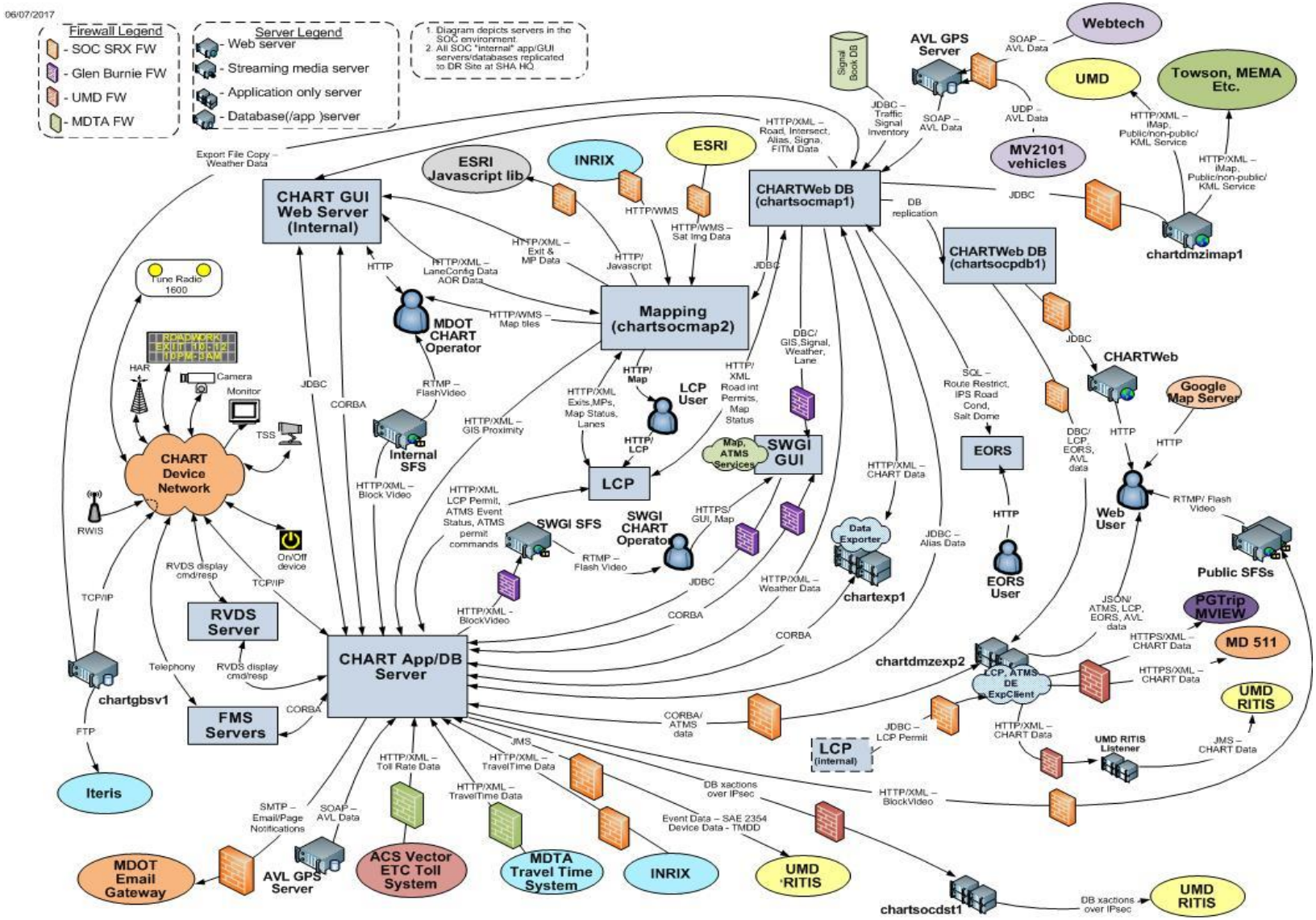

Figure 6-1. CHART High Level Data Flow

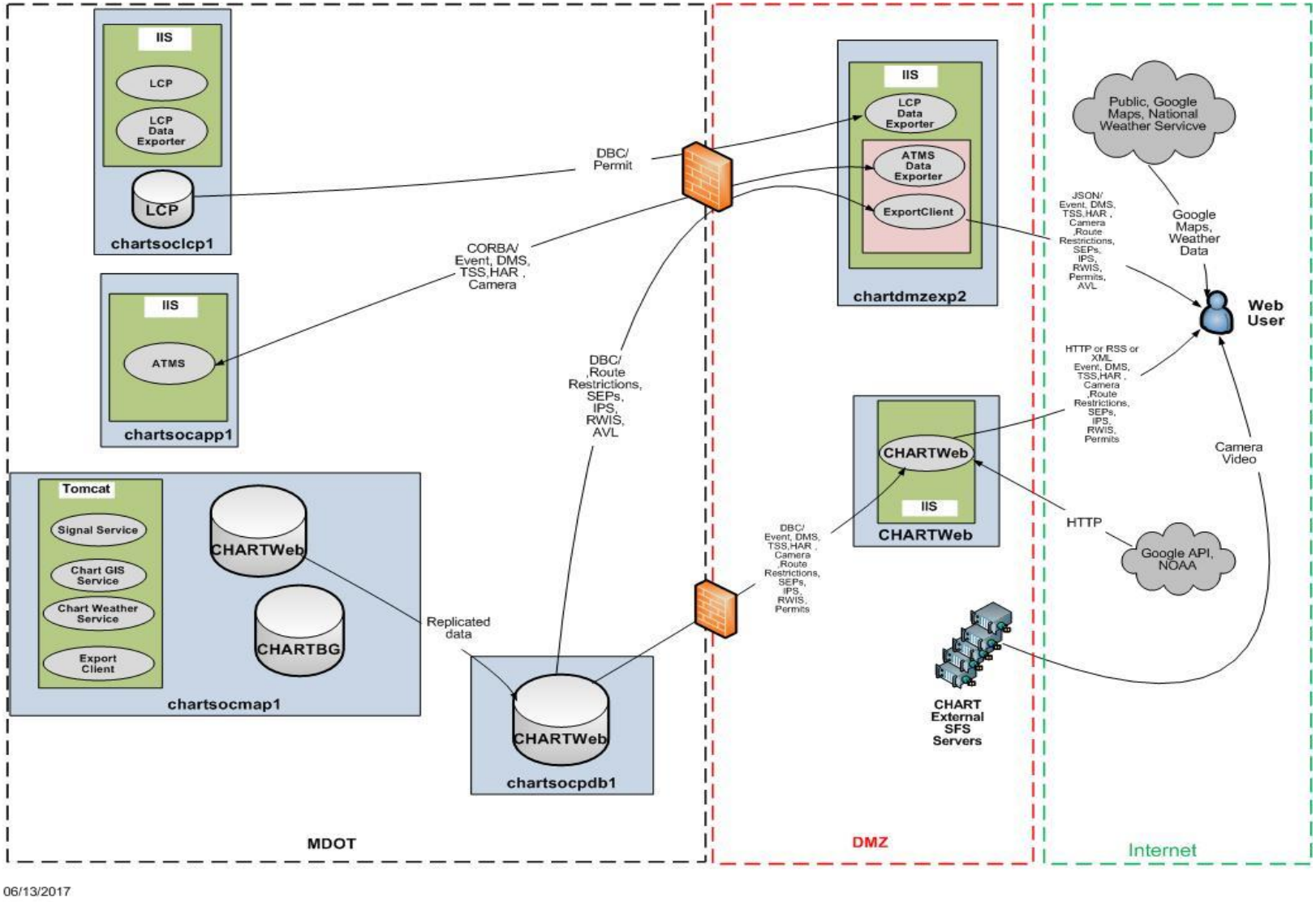

Figure 6-2. CHARTWeb Detailed Data Flow

6.3 Database

This section describes the CHARTWeb operational database design, at a high level. The CHARTWeb Public database is designed exclusively for the CHARTWeb application with data mirrored from the internal CHARTWeb Mapping database. With respect to the CHARTWeb application the mirrored database design consists of these major areas:

- Traffic camera data
- Traffic incident data.
- Lane closures data.
- Route restrictions data.
- Local weather station data.
- Speed sensor data.
- Highway message sign data.
- Snow emergency plan data.
- Weather related road conditions.
- Automatic Vehicle Locator data.

6.3.1 Traffic camera data

The traffic camera data includes the feed ID, video server IP address, location, latitude and longitude for traffic camera video feeds that may be provided to the public. This data is maintained by the CHART ATMS application.

6.3.2 Traffic incident data

The traffic incident data includes the type, location and description of current traffic incidents. This data is maintained by the CHART ATMS application.

6.3.3 Lane closure data

The lane closures data includes location and descriptions for weather road closures, active construction and maintenance closures. This data is maintained by both the LCP and the CHART ATMS applications.

6.3.4 Route restrictions data

The route restrictions data includes the location, description and type of commercial vehicle route restriction. This data is maintained in the EORSV2 application.

6.3.5 Local weather station data

The local weather station data includes the location, description and weather related data for RWIS devices. This data is maintained in the Lufft SmartView application.

6.3.6 Speed sensor data

The speed sensor data includes the location, name and speed data for a roadside speed sensor. This data is maintained in the CHART ATMS application.

6.3.7 Highway message sign data

The highway message sign data includes the location, ID and message for highway message signs. This data is maintained in the CHART ATMS application.

6.3.8 Snow emergency plan data

The snow emergency plan data includes the county, start time, time lifted and exceptions for snow emergencies in Maryland. This data is maintained in the EORSV2 application.

6.3.9 Weather related road conditions data

The weather related road conditions data includes the travel conditions for interstate, primary and secondary routes during winter storm events in Maryland. This data is maintained in the EORS application.

6.3.10 Automatic Vehicle Locator data

The Automatic Vehicle Locator data for select SHA and MDTA vehicles in Maryland. This data is collected by the AVL-GPS Server application.

7 DEPLOYMENT VIEW

7.1 View Description and Typical Stakeholders

The deployment view describes the physical locations of servers and services. This view is useful for Operations and Maintenance personnel to identify relationships within and between servers. Network engineers may be particularly interested when identifying which protocols are expected between any pair of servers in the system.

7.2 Deployment Configurations

The nominal CHARTWeb software service configuration is shown in the table below. Under normal conditions the primary servers execute all CHARTWeb services. In a fail-over situation, the failover virtual environment supports all CHARTWeb application services.

Table 7-1. CHARTWeb Deployed Services Per Site

Site	Server	Purpose	Service Name
GB-DC	dmzchartweb	CHARTWeb Desktop Application	World Wide Web Publishing Service

7.3 CHARTWeb Network/Deployment Diagram

Figure 7-1 shows the network diagram for CHART, including CHARTWeb.

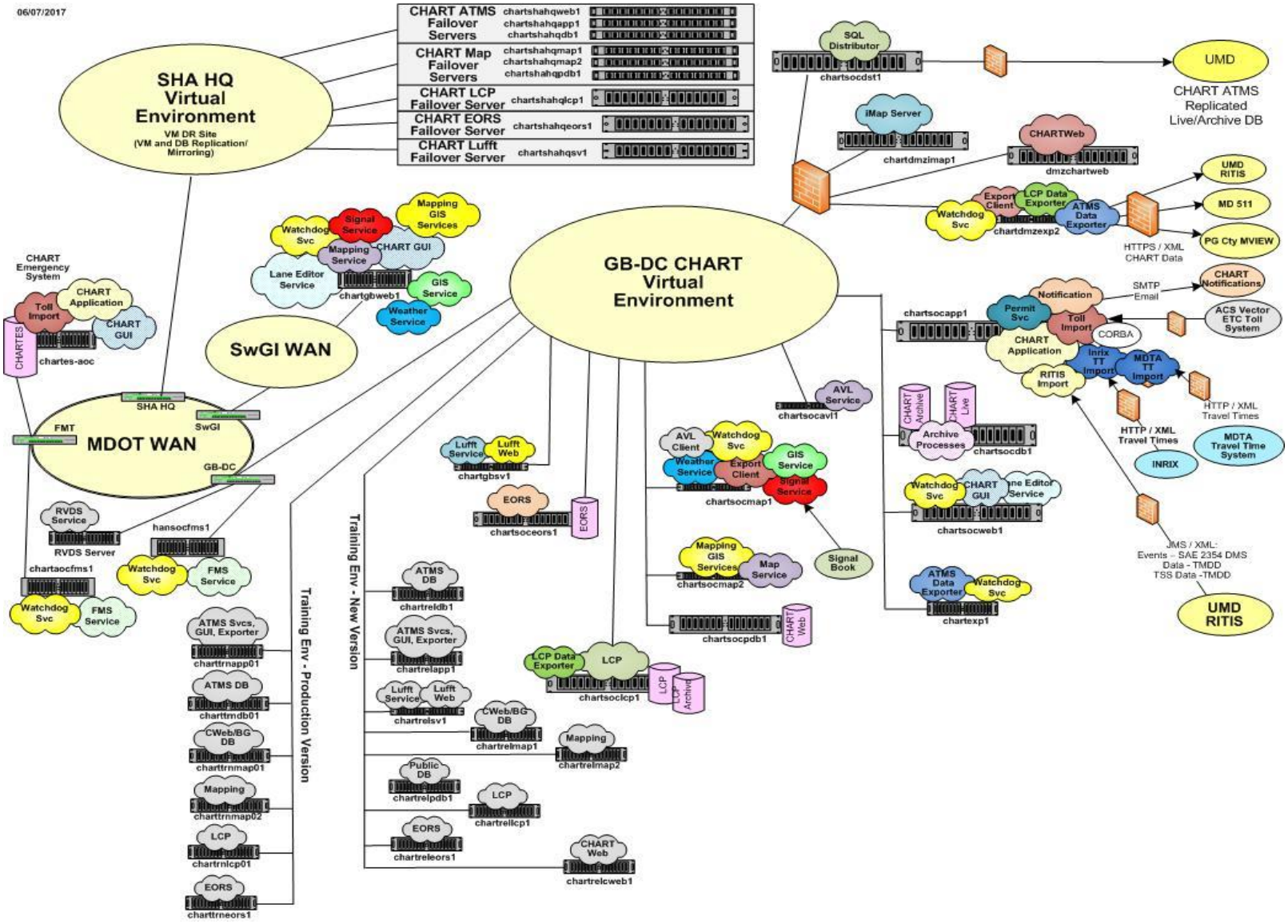

Figure 7-1. CHART Server Deployment

7.4 Facilities

This section presents the recommended deployment of hardware at each facility.

7.4.1 Node Sites

CHARTWeb database and application servers are primarily located at the MDOT Glen Burnie Data Center (GB-DC). The GB-DC houses the CHART virtual environment and is the central site for the coordination of CHART activities. The list below describes the equipment to be deployed at each site.

1. GB-DC –

   Virtualized CHARTWeb application server

   Virtualized CHARTWeb Public database server

7.5 System Management and Support

This section discusses CHART system management activities and support provided for system monitoring and problem tracking.

7.5.1 Data Backup and Recovery

vRanger is used to create snapshots of the virtual machines then copies them to the failover site (Baltimore SHA HQ). The procedures responsible for performing the backups run automatically and require only periodic checks from CHARTWeb personnel to verify correct operation.

The system architecture and design minimizes the likelihood of having to recover an entire disk volume. The use of RAID 1 and RAID 5 arrays means that the system can perform self recovery in most instances. A more likely scenario would be the recovery of data due to corruption of some type. By taking periodic snapshots of the mission critical data and maintaining the Virtual Machine (VM) snapshots for a reasonable period of time a corrupted file could be restored to its last uncorrupted state.

7.5.2 System Monitoring

Transportation Business Unit (TBU) personnel monitor CHARTWeb servers performance using Veeam ONE.

7.5.3 Problem Identification and Tracking

The CHART project uses the problem tracking tool JIRA to support CHART system problem reporting and tracking. Problems discovered prior to delivery of a release to operations are handled as described in the *CHART Change Management Plan*. Problems discovered in production are handled as described in the same document.

Problems discovered by operations personnel are logged by TBU or NOC personnel in the NOC's Maximo system. Problems determined to be CHARTWeb software problems are documented in Jira for tracking and resolution.

8 SUBSYSTEM VIEW

8.1 View Description and Typical Stakeholders

The Subsystem View describes the subsystems of the CHARTWeb application, their purpose, and how they are used. It describes all the COTS used in the system, and the source, version, usage, and redistributability of all the COTS. This view will be of primary use to developers, configuration managers, and management of CHART.

8.2 Software Subsystems

Table 8-1 lists each software and hardware Configuration Item (CI) and the subsystems comprising the CI. The sections that follow provide functional descriptions for each CI.

CHARTWeb is dependent upon network services provided through the MDOT backbone network. The management and control of the network is outside the scope of this document.

Table 8-1. CHART Mapping Configuration Items and Subsystems

CI Name	Subsystems
CHARTWeb Desktop Web Application Web Services	World Wide Web Publishing Service (IIS)
Database Instance	CHARTWeb Public DB
COTS	.NET framework 4.5 PHP ASP Microsoft Visual Studio Ultimate 2013 Microsoft SQL Server Microsoft Windows Subversion Subversion browser TortoiseSVN

8.2.1 CHARTWeb Desktop Application Web Services

The software services comprising the CHARTWeb Desktop Web Application Web Services CI are briefly described below.

8.2.1.1 World Wide Web Publishing Service

This service is used to provide the ASP.NET Web API, PHP and ASP services that provide the CHARTWeb Desktop Web Application Web Services to external entities.

8.2.2 Database Instance Subsystems

There is only one software subsystem comprising the Database Instance CI. This subsystem is briefly described below.

8.2.2.1 Public DB

This subsystem comprises the live Microsoft SQL Server databases used by CHARTWeb which stores all CHARTWeb related data.

The CHARTWeb Public database contains a mirrored subset of datafrom the Intranet Mapping database which is mirrored to the SHA Headquarters backup site for redundancy purposes.

8.2.2.1.1 Mirroring

8.2.2.1.2 Query

This subsystem provides the ability to query the database, for purposes of examining the database and manipulating data in the database, from a program perspective and via the SQL Management Studio, and also, not formally part of the CHARTWeb application.

8.2.3 COTS

The COTS CI collects all COTS packages into a single CI for configuration control purposes. This CI is used to track the COTS packages and versions used. Rather than list each subsystem in paragraphs, the COTS packages used throughout the system are described in Table 8-2 below. Package redistributability is designated as Open source, Free (freely available, but without source), or Proprietary (purchased or otherwise restricted). Usage is listed as Development, Runtime, both Development and Runtime, or Administrative. For COTS that is both Development and Runtime, the predominant usage, if that makes sense, is listed first. Administrative usage is listed when the product is not required to build the system, even if the product is a key part of the development effort, such as Microsoft Visual Studio, which developers use extensively.

Table 8-2. COTS Packages

Product Name	Version	Description/Purpose	Redistributability	Usage
Microsoft SQL Server	2008 R2	CHARTWEB uses Microsoft SQL Server 2008 to host its databases.	Proprietary	Runtime
Microsoft Visual Studio (including .NET 4.5)	2013 Ultimate	CHARTWEB uses Microsoft Visual Studio 2012 Ultimate for C# source code development. Necessary library files are used in the runtime environment.	Proprietary	Development Runtime
Microsoft Windows	2008 Server	CHARTWEB uses Microsoft Windows 2008 Server as its standard runtime platform for the CHARTWEB application/database servers.	Proprietary	Runtime
RedGate SQL Backup Pro	6	CHARTWEB uses these parts of the RedGate DBA Bundle monitoring tools to support the backup and restore processes and to monitor database performance	Proprietary	Runtime
RedGate SQL Monitor	2.3.0			
Sparx Enterprise Architect	9.3.934	CHARTWEB developers use Enterprise Architect by Sparx for UML modeling and design tool.	Proprietary	Administrative
Subversion	1.6	CHARTWEB uses Apache Subversion for source code control.	Open source	Development
Subversion browser TortoiseSVN	1.6.15	Official CHARTWEB builds use TortoiseSVN subversion browser. Some developers may use TortoiseSVN as well.	Open source	Development
vRanger Backup & Replication	5.3.1	The CHART Program uses vRanger Backup & Replication by Quest Software to maintain system backups. This subsystem is not part of the CHARTWEB per se, but serves in a support role. Therefore it is listed as having Administrative usage, rather than Runtime usage.	Proprietary	Administrative
XML Spy	2009 Pro SP 1	CHARTWEB developers use XMLSpy to visualize, edit, and generate XML and XSLT used by the CHARTWEB and by some of the external systems which interface with the CHARTWEB.	Proprietary	Development

9 STANDARDS VIEW

9.1 View Description and Typical Stakeholders

This view into the CHARTWeb applications describe how CHARTWeb supports interoperability through the .NET Web API. This view is useful for MDSHA management, CHARTWeb developers, and those looking to interface with CHARTWeb for the purpose of consuming/display CHARTWeb data.

9.2 Standards Overview

The CHARTWeb application sits on the Microsoft .NET Architecture and supports a number of interoperability standards.

The CHARTWeb application supports multiple approaches to interoperability:

- Web—XML, JSON
- Enterprise Integration—XML, SQL
- Application Content—PDF

10 BUSINESS ARCHITECTURE VIEW

10.1 View Description and Typical Stakeholders

This section provides a view into how the CHART Program aligns with the CHART Business Area Architecture, which lays out the business case and business objectives for CHART, and attempts to align those with current and desired future capabilities. This section lays out a business strategy for achieving those goals, in line with available and long-term resources. Interested stakeholders would include MDSHA management and CHART Program Management, especially those who participated in the BAA process, or those would like to learn more about CHART's business plan and its mapping to CHART capabilities.

10.2 Business Area Architecture

CHARTWeb relates to a number of BAA current and future requirements under the broad category of providing Traveler Information.

Inputs to CHARTWeb include:

- Event updates (traffic events, including road work)
- Device activation information and status (DMS, HAR)
- Road conditions – queue length, travel times, traffic flow (as monitored by speed detectors and cameras)
- Road conditions – pavement and weather conditions
- Alternate route recommendations

Figure 10-1, from the BAA, summarizes the Business Process Model. For more detail, see the full breakdown in Appendix B of the CHART Business Area Architecture

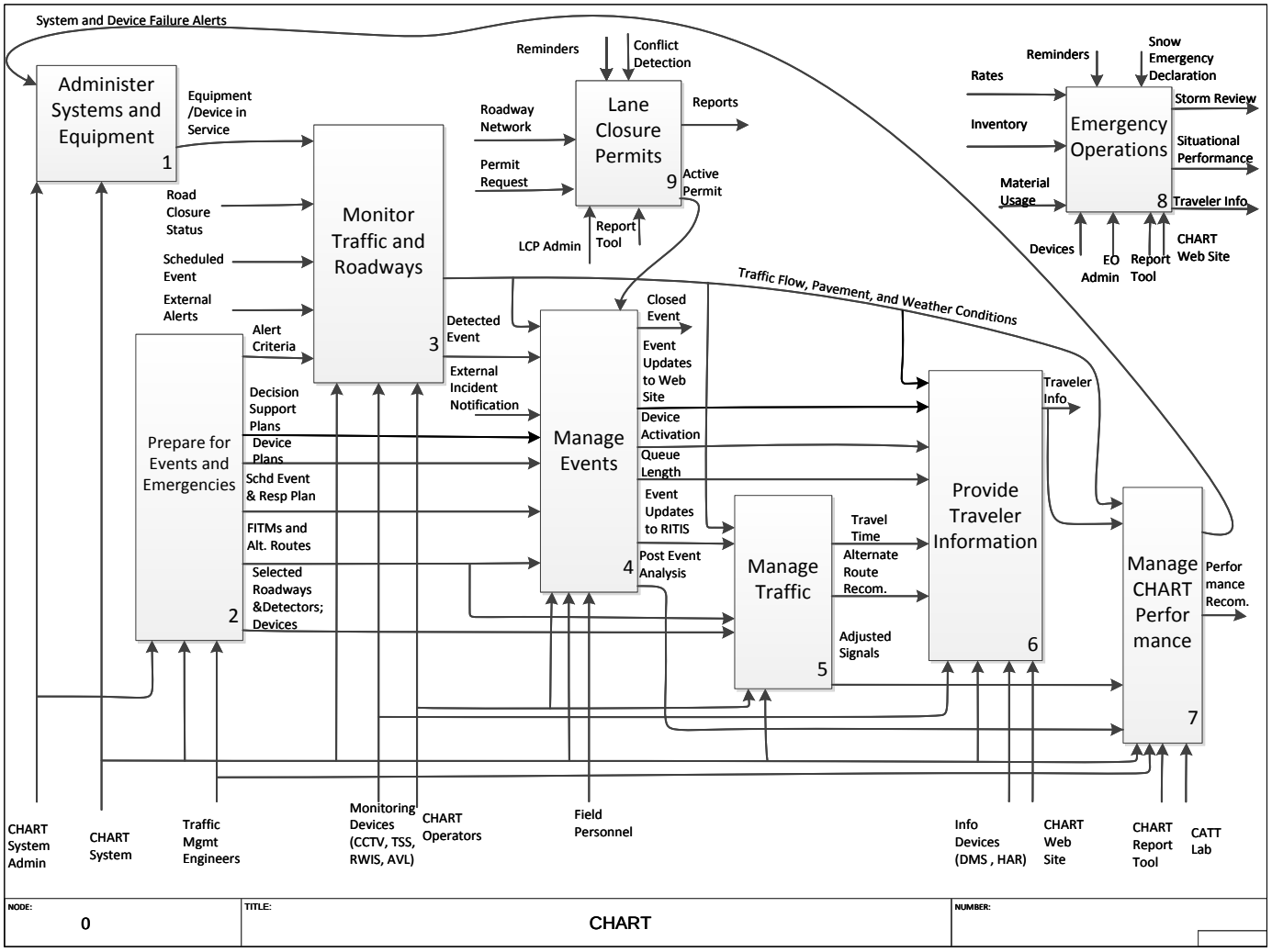

Figure 10-1 CHART High Level Business Process Model

10.3 Future CHARTWeb Releases

Future releases of CHARTWeb as documented in the BAA:

Table 10-1 CHARTWeb Future Release Functions

CI	Subsystem	Function
CHARTWeb	CHARTWeb	Provide 511 functionality
CHARTWeb	CHARTWeb	Improved Lane Diagrams and Descriptions
CHARTWeb	CHARTWeb	Implement Circles and Intersections

10.4 Near Term Goals

10.4.1 Provide 511 Functionality

CHARTWeb will be enhanced to provide a subset of MD 511 functionality, so that MD 511 may be retired.

11 SYSTEM MAINTENANCE VIEW

11.1 View Description and Typical Stakeholders

This section provides a view into the high level CHARTWeb maintenance tasks. This includes system maintenance (including backup and recovery), database maintenance, and routine software maintenance. The CHARTWeb Operations and Maintenance Guide contains much more detailed information on these routine maintenance tasks. Interested stakeholders would be system administrators, software and system architects, and any other parties interested in a high level view of maintenance tasks for CHARTWeb.

11.2 Data Backup and Recovery

Data backup and recovery are implemented at both the system level and the database level. Database level backups are needed in order to guarantee transactional integrity and to prevent database backup corruption.

11.2.1 Data Backup

11.2.1.1 Virtual Environment

Procedures for backing up the virtual environment are not covered in the CHARTWeb Operations and Maintenance Guide. These tasks are performed by Transportation Business Unit (TBU) personnel following procedures maintained by TBU staff. Most of these procedures can be found in the CHART Virtualization Operations and Maintenance Guide.

The ability to "snapshot" a virtual server provides the ability to roll back a server to a previous state should an issue occur with that server, and simplifies maintenance and administration by allowing patches and upgrades to be easily and quickly backed out if necessary.

Full image snapshots are taken nightly and copied to an offsite location at SHA Headquarters (HQ) in Baltimore. Included in these snapshots are local snapshots with file and image-level restore functionality.

11.2.1.2 Database

Backup jobs are run using the SQL Backup tool by Redgate. Those tasks include:

Full database backup

Transactional database backup

Differential backup

11.2.2 Data Recovery

11.2.2.1 Virtual environment

The site at SHA HQ exists as a redundant and disaster recovery capable location where individual pieces or the entire suite of CHART applications (CHART ATMS, CHART Mapping, LCP, etc.) can exist if necessary. All CHART servers may be instantiated at SHA HQ, including both the CHARTWeb server and other servers within the CHART enterprise, including a number

of applications that CHARTWeb interfaces with. Should a full site recovery at SHA HQ be necessary, all non-database data would be recovered within a datastore replication window. For CHARTWeb, all relevant data is stored in the database and the database recovery process is executed as an additional step after servers have been instantiated at SHA HQ.

11.2.2.2 Database

Database recovery is performed by Transportation Business Unit (TBU) personnel following procedures maintained by TBU staff:

Recovering database backup

Recovering mirrored database from SHA HQ

Utilizing mirrored database at SHA HQ

11.3 System Monitoring

Cern Virtual Infrastructure (CVI) administrators will access the environment through a variety of tools, depending upon the task and required method of access.

11.3.1 Virtual environment

The vSphere Web Client provides the most comprehensive access to the VMware environment, allowing administrators to add, delete, modify, move, and monitor the physical and virtual machines. "Console" access is granted through this tool, as well as providing basic monitoring and environmental health visible through the client. A traditional "thick" client may be downloaded via web browser using the address of the vCenter server, one of the individual hosts, or from www.vmware.com.

A Secure Shell (SSH) client, such as Putty, may be used for access into the root console of the VMware hosts for administration or maintenance that is not available within the vSphere Client. This typically is used for application of hotfixes and upgrades to the physical hosts, detailed log viewing, or high-level administrator activities.

Veeam provides monitoring capabilities with limited access to virtual machines and physical hosts. Veeam is accessed via web browser through a specific port for both monitoring and configuration. Veeam is used to monitor CPU usage, memory usage, disk usage, and I/O statistics, etc. Veeam can generate alarms and notifications based on defined thresholds.

Integrated Lights-Out (iLO) provides access to the HP hardware, which can be managed from the Blade Enclosure management connection, or from a web browser pointed to the correct IP address. In addition, hardware can be managed from a Liquid Crystal Display (LCD) screen on the front of the blade enclosure, directly connecting into the blade via a dongle connection, or through keyboard-video-mouse (KVM) switch connection to the Storage Area Network (SAN) or Blade hardware.

11.3.2 Database

Database backup jobs are monitored using Red Gate SQL Backup tools. Specific tasks include:

Observing last backup run time and status

Check of physical file backup on the appropriate server

The database mirroring process is also monitored using Red Gate tools.

11.4 High Availability

The CHART system design provides high availability through these methods.

Redundancy within virtual environment

Redundancy of communications paths

Database mirroring

Offsite backup capabilities for CHART Mapping and the entire virtual environment

Each of these methods will be discussed in more detail below.

11.4.1 Redundancy within the Virtual Environment

The CHART Virtual Infrastructure provides redundancy through the implementation of a cluster of hardware and software packages.

The CHART Virtual Infrastructure provides redundancy through the implementation of a cluster of hardware and software packages.

- Storage is provided by a SAN cluster with redundant network connections accessible by all devices. This storage is replicated regularly to the SHA HQ site. The current configuration allows several individual component failures within the SAN without loss of data or the need to fail over, as well as the ability to perform file-level recovery and full image restoration if needed.
- Hardware hosting the virtual servers provides protection against data and service loss with several components having 100% redundancy. For instance, the "Flex 10 networking modules" are completely redundant. The physical hosts themselves can tolerate the loss of 1/3 of the available physical hosts and still maintain full capabilities when the impacted virtual hosts are moved to the remaining physical hosts(s).
- Network and power redundancy are also at 100% with the ability to lose a full network or power feed without adversely affecting the environment.
- VM Application and hardware configuration provides automatic failover of many components, including the ability to distribute resources, re-locate virtual servers on demand, take snapshots of servers prior to updates/upgrades, etc.

11.4.2 Redundancy of Communications Paths

There are redundant or backup communications paths for the CHART Backbone network traffic.

11.4.3 Database Mirroring

SQL Server mirroring has been established between the databases at the principal node at the MDOT Glen Burnie Data Center (GB-DC) and mirror node at the SHA HQ data center. A single identically configured server resides at each of the nodes from both a hardware (virtual) and software perspective.

As database transactions are committed in the principal node these transactions are copied over to the mirror node. The copying happens in real time and the data is in a synchronized state between the nodes. The level of synchronization can be set to be either dual commit or single commit mode. In a dual commit mode the database transaction is written to both nodes and only then will the relevant locks be released. In a single commit synchronization mode, transactions

are committed at the principal node and locks are released. As a follow-on action these transactions are forwarded to the mirror node.

The CHARTWeb database is configured in a single commit synchronization mode. In a future release, the CHARTWeb application could be modified to take advantage of automatic failover, in which case the dual commit synchronization mode with automatic failover could be used.

In case of a database failure at the principal node, the CHARTWeb database will be manually failed over to the mirrored node.

11.4.4 Offsite Backup Capabilities for the Virtual Environment

Full image snapshots are taken nightly and copied to the SHA HQ location in Baltimore. Included in these snapshots are local snapshots with file and image-level restore functionality.

The site at SHA HQ exists as a redundant and disaster recovery capable location where individual pieces or the entire CHART system can exist if necessary. Currently, the entire CHART network at the GB-DC can be failed over to SHA HQ. Details are provided in the CHART Virtualization Operations and Maintenance Guide.

11.5 Software Distribution

This section presents the procedures and processes used to control and manage the development and distribution of the CHARTWeb software.

11.5.1 Configuration Management and Version Control

The overall Configuration Management (CM) plan for CHART is presented in the document "CHART Change Management Plan". The specific objectives of the CHART CM program are to ensure that:

- CHART hardware, software, and data configuration items (CIs) are appropriately selected and identified
- CHART project baselines are established at the correct time
- Changes to the CHART baselines are authorized, evaluated, implemented as approved, verified, and tracked in accordance with established procedures
- Commercial off-the-shelf (COTS) tool upgrades are fully assessed and their impact evaluated
- The status of CHART baselines and proposed and approved changes is accounted for and reported
- Baseline and other required CM audits are carried out and the results reported
- The integrity of the system design is maintained
- The delivered system and all accompanying deliverables are accurately defined and described

The CHARTWeb development team is using Subversion as the configuration management tool to support CHARTWeb software development. The configuration management policies and procedures for the CHARTWeb software are defined in a set of standards and procedures documents. These standards and procedures documents are listed below.

CHART Change Management Plan.

11.5.2 Software Installation

The installation of new versions of CHARTWeb software components is controlled as described in the *CHART Change Management Plan*. The detailed plan for executing the installation is contained in the CHARTWeb Implementation Plan that is customized for each CHARTWeb software release. For new site installations the software components are installed and configured prior to integration of the system into the operational environment. Appendix A of the CHARTWeb Operations and Maintenance Guide presents instructions for performing software installations on operational system components. This includes installation of both COTS and of the CHARTWeb software proper.

11.6 Training

Training plans are not required for CHARTWeb.

LIST OF ACRONYMS

The following table lists the acronyms used in the document.

Acronym	Description
AOC	Authority Operations Center
AOR	Area of Responsibility
API	Applications Programming Interface
ATMS	Advanced Traffic Management System
AVL	Automatic Vehicle Location
BAA	Business Area Architecture
BHT	Baltimore Harbor Tunnel
CATT	Center for Advanced Transportation Technology
CCTV	Closed Circuit Television
CHART	Coordinated Highways Action Response Team
CM	Configuration Management
COTS	Commercial Off-The-Shelf
CVI	Cern Virtual Infrastructure
DB	Database
DBA	Database Administrator
DCDOT	District of Columbia Department of Transportation
DMS	Dynamic Message Sign
EORS	Emergency Operations Reporting System
ER	Entity Relationship
ERD	Entity Relationship Diagram
ESRI	Environmental Systems Research Institute
FC	Fibre Channel
FITM	Freeway Incident Traffic Management
FMT	Fort McHenry Tunnel
FSK	Francis Scott Key [Bridge]
GB-DC	MDOT Glen Burnie Data Center
GUI	Graphical User Interface
HA	High Availability
HAR	Highway Advisory Radio

Acronym	Description
HIS	Highway Information Systems
HISD	Highway Information Services Division
HP	Hewlett-Packard
HQ	Headquarters
HTTP	Hyper Text Transfer Protocol
HTTPS	Hyper Text Transfer Protocol Secure
I	Interstate
ICD	Interface Control Document
iLO	Integrated Lights-Out
IP	Internet Protocol
iSCSI	Internet Small Computer System Interface
ISDN	Integrated Services Digital Network
JSON	JavaScript Object Notation
KVM	Keyboard-Video-Mouse [Switch]
LCD	Liquid Crystal Display
LCP	Lane Closure Permits
MD	Maryland
MD511	Maryland 511 (Maryland's 511 Traffic information System)
MDOT	Maryland Department of Transportation
MDSHA	Maryland State Highway Administration
MDTA	Maryland Transportation Authority
NOC	Network Operations Center
NTCIP	National Transportation Communication for ITS Protocol
PR	Problem Report
REST	Representational State Transfer
RITIS	Regional Integrated Transportation Information System
RSS	Really Simple Syndication
RTMS	Remote Traffic Microwave Sensor
SAN	Storage Area Network
SCSI	Small Computer System Interface
SFS	Streaming Flash Server
SHA	State Highway Administration
SHAZAM	Sign with controllable beacons to indicate a message of significance is playing on a

Acronym	Description
	nearby HAR. (SHAZAM is not an acronym.)
SOC	Statewide Operations Center
SOP	Standard Operating Procedure(s)
SP	Service Pack
SSH	Secure Shell
SSP	Safety Service Patrol
SwGI	Statewide Government Intranet
TCP	Transmission Control Protocol
TOC	Traffic Operations Center
TSS	Transportation Sensor System
UMD	University of Maryland
US	United States
vCPU	Virtual CPU
VM	Virtual Machine
WAN	Wide Area Network
WMS	Web Map Service
WYSIWYG	What You See Is What You Get
XML	Extensible Markup Language

A DESIGN STUDIES

This section provides information on analysis, prototyping, and trade studies dating from the initial system design effort to the current time.

A.1 CHART Systems Database Strategic Plan

The purpose of this study, completed in April 2011, was to identify database options for the full CHART Program that would maximize technical and financial benefit to SHA's business goals. The subsequent CHART Work Order Scope and Estimate Request Form requested the production of a white paper document to recommend a 5 year strategic plan for the CHART systems databases and also, after a checkpoint with SHA, to create a plan including a schedule, assumptions and risks to implement the approved recommendations.

The assessment was approached using the Enterprise Architecture Framework as defined by the National Institute of Standards and Technology. This approach gives a holistic view of the enterprise. The Enterprise Architecture has 5 layers. The five layers are:

- Enterprise Business Architecture Layer
- Enterprise Information Architecture Layer
- Enterprise Application Architecture Layer
- Enterprise Application Integration Architecture Layer
- Enterprise Infrastructure Architecture Layer

The Enterprise Business Architecture Layer review for SHA was carried out previously by CSC and is reflected in the Business Area Architecture document: BAA Report Revision 6, January 2011. The recommendation for this layer was to continue on those specified in BAA.

The Enterprise Information Architecture Layer is comprised of the Presentation Management and Reports Management layers. In the Presentation Management layer of SHA, there are several Graphical User Interfaces identified. These are CHART GUI, EORS V2 GUI, LCP (known as EORS Legacy at the time) GUI, CHARTWeb Desktop, CHARTWeb Mobile and the Intranet Map. The recommendation for this layer was to establish a single EORS (LCP) GUI, establish CHART Analytics GUI, establish an Attention Admin GUI and continue to use the following GUIs; CHARTWeb Mobile, CHARTWeb Desktop, CHART GUI, Intranet Map (ArcGIS) and implement a portal tool that will unify and enable a role-based Single-sign on.

In the Reports Management portion of the Enterprise Information Architecture, several report conduits were identified: SREE, SQL Server Reporting Service, Legacy Reporting Service, and Google Web Analytics Lite. The recommendation for this layer was to retire SREE, consolidate all SQL Server Reporting services, establish CHART dashboards, CHART Analytics (Business Intelligence tool) and use Google Urchin.

The Enterprise Application Architecture Layer is comprised of four core applications, which are the CHART ATMS, LCP (EORS at that time), CHARTWeb and CHART Mapping. The recommendation at this layer was to continue to have the applications remain independent of each other and integrate in the middleware layer.

The Enterprise Application Integration Architecture Layer is comprised of the middleware/IPC management layer. The CHART middleware management is using CORBA, Apache Tomcat, IIS, ASP, .NET, RSS, XML Web Services, and REST Web Services. The recommendation for this layer was that CHART is already on a good path and should continue to

use Tomcat, IIS, ASP, .NET, RSS, and Apache. It was recommended that CHART implement an Enterprise Service Bus (ESB), establish web orchestration using BPEL, establish a form of Workflow mechanism using BPM, and establish a Web Services Manager and Service Registry. These middleware upgrades could possibly lead to the replacement of CORBA as an IPC solution for the CHART ATMS at some point in the future.

The Enterprise Infrastructure Architecture Layer is comprised of Database Management; Archive and Backup Management; and the physical Infrastructure Management. The recommendation for the Database Management portion was for SHA to use web services for communication and take the "Federated Option" which consists of the following components:

Attention Database (paging system)

A consolidated CHART Database

CHART BG Database (SDE & Mapping)

A consolidated database for LCP (EORS at that time)

CHART Web Cache Database

CHART Analytics Database (CHART-A)

This recommended approach would give SHA flexibility for growth, while systems and development cycles remain independent. It also provides a quicker patching cycle and keeps all application communication at the middleware layer. At the database layer, the recommendation is to consolidate databases where possible and implement an enterprise data governance strategy. The recommendation for the physical Infrastructure Management portion is for SHA to continue on the path of establishing VMware ESXi and upgrading to a more recent version of the Windows Server operating system. The ArcServe Backup product recommended by CHART's infrastructure team will be implemented

B RELEASE HISTORY

CHART systems have been evolving over a long period of time. The CHARTWeb applications have only recently began issuing formal releases as most of the previous updates were done out of cycle.

C.1 WO 29 Task 87 CHARTWeb UI Upgrade

The WO 29 Task 87 CHARTWeb UI Upgrade implemented a new set of HTML5/CSS3/JavaScript standards as defined by the Maryland DOIT WebCom templates. User interfaces for all areas of the CHARTWeb Desktop application were redesigned to comply with the new MD Statewide web templates and branding practices.

C.2 WO 47 CHARTWeb Map Architecture Refresh

Following is a summary of the major features provided by WO 47

- Add a caching mechanism to avoid going to the database for each request from the map.
- Add classes to hold data for each layer on the map (Camera, CCTV, DMS, Event, EORS Closure, EORS Restriction, External Camera, HAR, IPS, RWIS, SEP, and TSS).
- Rewrite handlers that provide data for the map to update the objects in the cache instead of returning XML to the map. One handler for each layer (Camera, CCTV, DMS, Event, EORS Closure, EORS Restriction, External Camera, HAR, IPS, RWIS, SEP, and TSS).
- Add code to return JSON to the map (instead of XML) based on the objects in the cache (using the extent of the viewport in the map).
- Convert the map from using the Google API to using OpenLayers 2.13.
- Add clustering support to the map.
- Update the Ajax support
- Add JavaScript code for each of the map layers (Camera, CCTV, DMS, Event, EORS Closure, EORS Restriction, External Camera, HAR, IPS, RWIS, SEP, and TSS).
- Added new Export Client to DMZ to provide near real-time data from LCP and CHART ATMS for the CHARTWeb map.

C.3 WO 53 CHARTWeb Map Architecture Refresh

Following is a summary of the major features provided by WO 53

- **CHARTWeb Traffic Cameras popup and page:** Will integrate Chart Web's Traffic Camera section with changes to CCTV export. Links and table will be generated using CCTV Export's new json feed instead of the current direct calls to database server. Traffic Cameras page will also be modified to remove the tabbed interface in favor of a navigation bar.
- **CHARTWeb Traffic Cameras RSS/XML feed:** The XML feed in CHARTWeb will now be created using CCTV Export's new json feed instead of its current direct call to the database server.

C.4 WO 56, CHARTWeb Map Architecture Refresh, CHARTWeb Release 3.2

Following is a summary of the major features provided by WO 56

- **Update Video Player to support HTML5:** Update JW Player from version 6 to version 7. This upgrade is already available to SHA under their current license. NOTE: HTML5 video feeds are not possible until changes are made to the video streaming appliance.
- **Route Based Camera List:** Create a new web page on CHARTWeb to provide a route-based list of traffic cameras.
- **Live Traffic Cameras:** Redesign the live traffic cameras page to utilize responsive tabs.
- **RWIS Detail page:** Update RWIS details page to conform to site design standards.
- **Provide real time data pages in format for display on smartphones:** Update the existing Maryland Highway and Traffic Information, Traffic Alerts and Planned Road Closures web pages to a mobile first, responsive user interface.

C.5 WO 12, Mobile Video, CHARTWeb Release 3.3

Following is a summary of the major features provided by WO 56, CHARTWeb Release 3.3.

- **AVL vehicles on CHARTWeb Map:** CHARTWeb was updated to provide a Winter Operations Vehicles Video Map**,** which displays SHA and MDTA AVL equipped vehicles. This includes location and video capabilities, for those vehicles equipped with cameras.

C.6 WO 14, JW Player Updates, CHARTWeb Release 3.4

Following is a summary of the major features provided by WO 14, CHARTWeb Release 3.4.

- **JW Player Updates:** CHARTWeb was updated to provide support for and deployment of JW Player 7.10.2. Also included were firewall updates to whitelist the JW Player callback URLs.

C.7 WO 14, JW Player Updates, CHARTWeb Release 3.5

Following is a summary of the major features provided by WO 14, CHARTWeb Release 3.4.

- **Remove JW Player Updates:** CHARTWeb was updated to remove all instances of JW Player
- **VideoJS Player Updates:** CHARTWeb was updated to replace JW Player with VideoJS.

The high level CHARTWeb architecture is shown below.

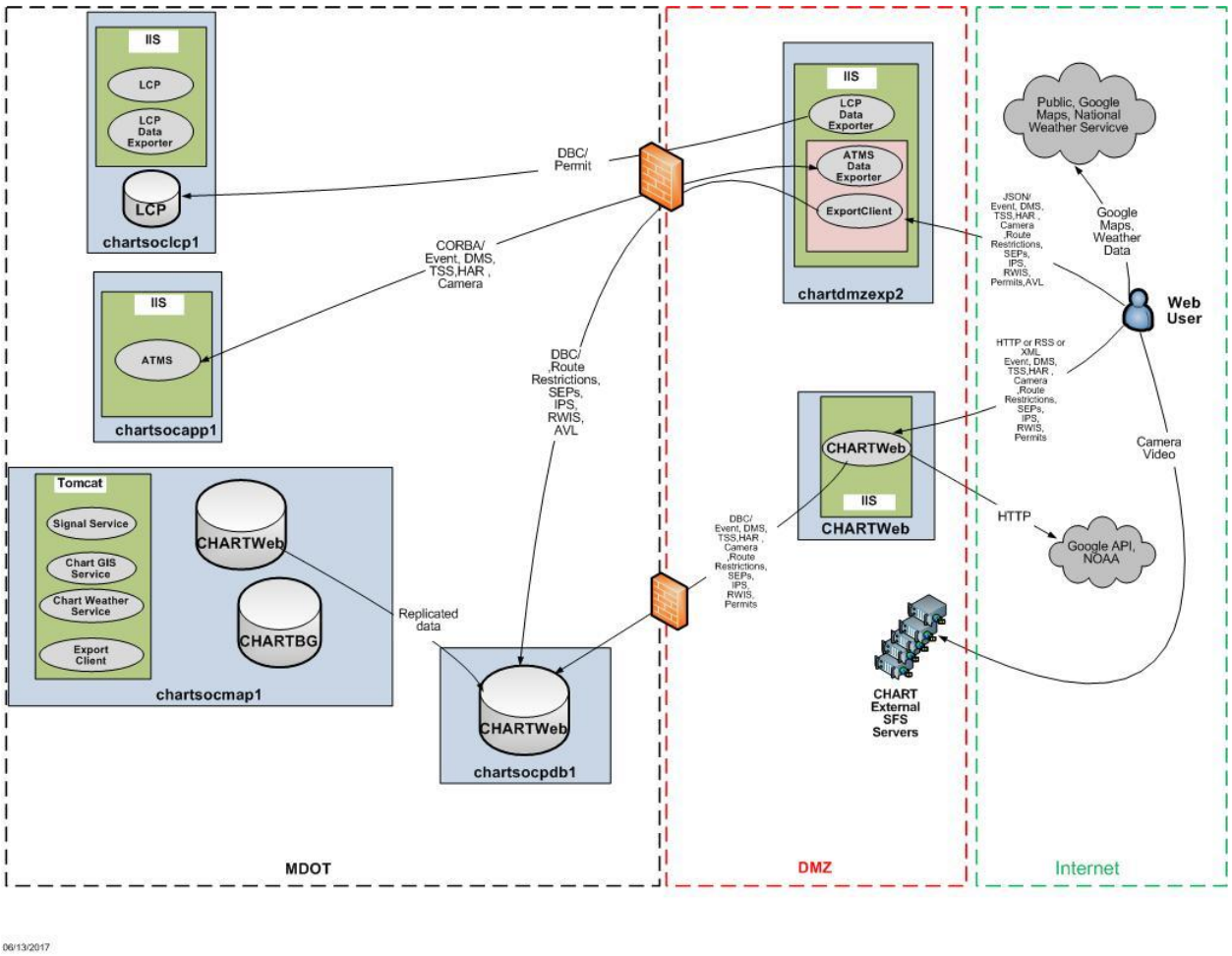

Figure C-1 CHARTWeb Release 3.3 High Level Architecture